TETRA TECH

# MEMO

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| *From:* | Michael Paul |
| *Date:* | August 29, 2019 |
| *Subject:* | Summary of narrative nutrient criteria interpretation for North Dakota |

## 1.1 INTRODUCTION

Lakes and reservoirs in North Dakota are important regional natural resources that, like most aquatic systems, are impacted by nutrients. Numeric criteria have been promoted as a way to better protect both these systems from nutrient enrichment and many states have adopted numeric nutrient criteria for lakes and reservoirs. North Dakota also has established guideline chlorophyll *a* criteria, but primarily relies on its narrative nutrient criterion.

This memo is our interpretation of how North Dakota is interpreting narrative nutrient criteria for the purposes of major water quality programs. It was our best effort based on existing and readily available documentation provided by the state. We view this as a point of departure for a fuller conversation with North Dakota Division of Water Quality (DoWQ) on how their narratives are interpreted and how existing numeric criteria were derived to inform the NSTEPS analysis project.

The sections include information on existing criteria and then how the criteria are interpreted for assessment and TMDLs. There was the most information on assessment. We did not find information relevant to permitting, but hopefully the state might provide some insight on that.

## 1.2 CRITERIA

- Narrative Criteria:
    - In 33.1-16-02.1-04 definitions

        7. "Eutrophication" means the process of enrichment of rivers, streams, lakes, reservoirs, and wetlands with nutrients needed to maintain primary production.
        8. "Nutrients" mean the chemical elements, primarily nitrogen and phosphorus, which are critical to the growth of aquatic plants and animals.

    - In 33.1-16-02.1-08. General water quality standards.

        - 1. Narrative standards.

        a. The following minimum conditions are applicable to all waters of the state except for class II ground waters. All waters of the state shall be:

(2) Free from floating debris, oil, scum, and other floating materials attributable to municipal, industrial, or other discharges or agricultural practices in sufficient amounts to be unsightly or deleterious.
(3) Free from materials attributable to municipal, industrial, or other discharges or agricultural practices producing color, odor, or other conditions to such a degree as to create a nuisance or render any undesirable taste to fish flesh or, in any way, make fish inedible.
(4) Free from substances attributable to municipal, industrial, or other discharges or agricultural practices in concentrations or combinations which are toxic or harmful to humans, animals, plants, or resident aquatic biota. For surface water, this standard will be enforced in part through appropriate whole effluent toxicity requirements in North Dakota pollutant discharge elimination system permits.
(6) Free from nutrients attributed to municipal, industrial, or other discharges or agricultural practices, in concentrations or loadings which will cause accelerated eutrophication resulting in the objectionable growth of aquatic vegetation or algae or other impairments to the extent that it threatens public health or welfare or impairs present or future beneficial uses.

e. No discharge of pollutants, which alone or in combination with other substances, shall:
(1) Cause a public health hazard or injury to environmental resources;
(2) Impair existing or reasonable beneficial uses of the receiving waters; or
(3) Directly or indirectly cause concentrations of pollutants to exceed applicable standards of the receiving waters.

- 2. Narrative biological goal.

a. Goal. The biological condition of surface waters shall be similar to that of sites or water bodies determined by the department to be regional reference sites.
b. Definitions.
(1) "Assemblage" means an association of aquatic organisms of similar taxonomic classification living in the same area. Examples of assemblages include fish, macroinvertebrates, algae, and vascular plants.
(2) "Aquatic organism" means any plant or animal which lives at least part of its life cycle in water.
(3) "Biological condition" means the taxonomic composition, richness, and functional organization of an assemblage of aquatic organisms at a site or within a water body.
(4) "Functional organization" means the number of species or abundance of organisms within an assemblage which perform the same or similar ecological functions.
(5) "Metric" means an expression of biological community composition, richness, or function which displays a predictable, measurable change in value along a gradient of pollution or other anthropogenic disturbance.
(6) "Regional reference sites" are sites or water bodies which are determined by the department to be representative of sites or water bodies of similar type (e.g., hydrology and ecoregion) and are least impaired with respect to habitat, water quality, watershed land use, and riparian and biological condition.
(7) "Richness" means the absolute number of taxa in an assemblage at a site or within a water body.
(8) "Taxonomic composition" means the identity and abundance of species or taxonomic groupings within an assemblage at a site or within a water body.

- In 33.1-16-02.1-09. Surface water classifications, mixing zones, and numeric standards.

    - 1. Surface water classifications.
      i. Lakes and reservoirs. The type of fishery a lake or reservoir may be capable of supporting is based on the lake's or reservoir's geophysical characteristics. The capability of a lake or reservoir to support a fishery may be affected by seasonal or climatic variability or other natural occurrences, which may alter the physical and chemical characteristics of the lake or reservoir.

      Class Characteristics
        - Cold water fishery. Waters capable of supporting growth of cold water fish species (e.g., salmonids) and associated aquatic biota.
        - Cool water fishery. Waters capable of supporting natural reproduction and growth of cool water fishes (e.g., northern pike and walleye) and associated aquatic biota. These waters are also capable of supporting the growth and marginal survival of cold water species and associated biota.
        - Warm water fishery. Waters capable of supporting natural reproduction and growth of warm water fishes (e.g., largemouth bass and bluegill) and associated aquatic biota. Some cool water species may also be present.
        - Marginal fishery. Waters capable of supporting a fishery on a short-term or seasonal basis (generally a "put and take" fishery).
        - Not capable of supporting a fishery due to high salinity.

- Numeric Criteria:
    - In 33.1-16-02.1-09. Surface water classifications, mixing zones, and numeric standards
        - 3. Numeric standards.
          d. Lakes and reservoirs.
        - (1) The physical and chemical criteria for class I streams shall apply to all classified lakes or reservoirs listed in appendix II.
        - (2) In addition, a guideline for use as a goal in any lake or reservoir improvement or maintenance program is a growing season (April through November) average chlorophyll-a concentration of twenty µg/l.
        - (5) The numeric dissolved oxygen standard of five mg/l as a daily minimum does not apply to the hypolimnion of class III and IV lakes and reservoirs during periods of thermal stratification.
        - (6) The numeric dissolved oxygen standard of five mg/l as a daily minimum and the maximum temperature of eighty-five degrees Fahrenheit [29.44 degrees Celsius] shall not apply to wetlands and class 4 lakes.
        - (7) Lake Sakakawea must maintain a minimum volume of water of five hundred thousand-acre feet [61,674-hectare meters] that has a temperature of fifty-nine degrees Fahrenheit [15 degrees Celsius] or less and a dissolved oxygen concentration of not less than five mg/l.

**Summary of Oklahoma's Numeric Criteria (information pulled from North Dakota's WQS**

| Waterbody type | Subtype or Site | Parameter | Value |
|---|---|---|---|
| **Lakes/Reservoirs** | Statewide Guideline for improvement or maintenance (April-November average) | Chlorophyll-a | 0.020 mg/L |

## 1.3 ASSESSMENT APPLICATION/INTERPRETATION:

***The following is based on: Water Quality Assessment Methodology for North Dakota's Surface Waters (Revised December 2013)***

II. Water Quality Standards

This section reviews applicable standards and points out, specifically, in section D Narrative Water Quality Standards (p. 6):

- …These standards protect surface waters and aquatic biota from:
    - Eutrophication (particularly lakes and reservoirs);
    - Impairment of the biological community (exemplified by the Index of Biotic Integrity); and…

***Document contains details on Assessment Units (289 lakes and reservoir in 290 Assessment Units – Lake Sakakawea has two units)(p.7)***

***Document discusses sufficient and credible data requirements (pp. 9-10***):

- Water column…data are 10 years olf or less for…lakes and reservoirs, unless there is adequate justification to use older data…
- There should be a minimum of two samples collected from lakes or reservoirs collected during the growing season, April-November. The samples may consist of two samples collected the same year or samples collected in separate years.

C. Aquatic Life and Recreation Use Assessment Methodology for Lakes and Reservoirs (pp.19-24)

- Section references "free-froms" but does not reference 1.a.(6) free from nutrients standard, which therefore must have come after 2013?
- **Trophic status indicators are used by the Department as the primary means to assess whether a lake or reservoir is meeting the narrative standards**.
    - Highly productive lakes, termed "hypereutrophic," contain excessive phosphorus and are characterized by large growths of weeds, bluegreen algal blooms, low transparency, and low dissolved oxygen (DO) concentrations.
- For purposes of this assessment methodology, **it is assumed that hypereutrophic lakes do not fully support a sustainable sport fishery and are limited in recreational uses**, whereas mesotrophic lakes fully support both aquatic life and recreation use. Eutrophic lakes may be assessed as fully supporting, fully supporting but threatened, or not supporting their uses for aquatic life or recreation.
- Eutrophic lakes are further assessed based on: 1) the lake or reservoir's water quality standards fishery classification; 2) information provided by North Dakota Game and Fish Department Fisheries Division staff, local water resource managers and the public; 3) the knowledge of land use in the lake's watershed; and/or 4) the relative degree of eutrophication.

***Functionally, it appears the state uses a combined criteria with a range. Hypereutrophic lakes are impaired, mesotrophic are unimpaired, eutrophic lakes are "further assessed".***

- Since trophic status indicators specific to North Dakota waters have not been developed, Carlson's trophic status index (TSI) (Carlson, 1977) has been chosen to assess the trophic status of lakes or reservoirs.
  - Trophic status based on Secchi Disk Transparency (TSIS):
    - TSIS = 60 - 14.41 ln (SD)
    - Where SD = Secchi disk transparency in meters.
  - Trophic status based on total phosphorus (TSIP):
    - TSIP = 14.20 ln (TP) + 4.15
    - Where TP = Total phosphorus concentration in µg L-1.
  - Trophic status based on chlorophyll-a (TSIC):
    - TSIC = 9.81 ln (TC) + 30.60
    - Where TC = Chlorophyll-a concentrations in µg L-1.

***This document does not contain the specific thresholds for what is meso-, eu- and hypereutrophic, so it is not clear what those cutoffs are. Traditionally, a value from 60-70 has been used to define the hypereutrophic boundary, which equates to Secchi depths of 0.5 to 1.0 m, TP of 0.050 to 0.10 mg/, and Chlorophyll a of 0.020 to 0.055 mg/L. Seeing as ND uses 0.020 mg/L of Chlorophyll a as a guidelines, I assume they consider TSI of 60 as the hypereutrophic boundary***.

- In general, of the three indicators, it is believed that chlorophyll-a is the best indicator of trophic status, since it is a direct measure of lake productivity. Secchi disk transparency should be used next, followed by phosphorus concentration.
- When conducting an aquatic life and recreation use assessment for a lake or reservoir, the average trophic status index score should be calculated for each indicator. When the trophic status index scores for each indicator (chlorophyll-a, Secchi disk transparency, and phosphorus concentration) each result in a different trophic status assessment then the assessment <u>**should be based first on chlorophyll-a**</u>, followed by Secchi disk transparency. Only when there are not adequate chlorophyll-a and/or Secchi disk transparency data available to make an assessment should phosphorus concentration data be used.

***Questions:***

What about aquatic life use measures to go with your biological narrative? Phytoplankton, zooplankton?

Your narratives have free froms for taste and odor and these appear in your CALM under BU determinations for drinking water (Section D, p23). Have you thought about Methyl Isoborneol (MIB) or Geosmin?

Setcion F, agricultural use assessment cites to the toxicity free-from which reads: "Free from substances attributable to municipal, industrial, or other discharges or agricultural practices in concentrations or combinations which are toxic or harmful to humans, animals, plants, or resident aquatic biota." Any thought to using cyanotoxins given the increased prevalence of livestock/pet poisonings?

***The following is from the 2019 Integrated Report provided by ND DoWQ:***

<u>From Part IV. Surface Water Monitoring and Assessment Methodology</u>

Fish Kill Investigations (p. IV-18)

**Question:** Is winter dissolved oxygen an issue? It appears there are measurements. What is the extent of data and have they been linked to nutrients/chlorophyll during the summer/fall?

Harmful Algal Blooms (HAB) Surveillance Program (p. IV-19)

- Due to the significant health risks associated with blue-green algae blooms and cyanotoxins, the department has initiated a Harmful Algal Blooms (HABs) Surveillance Program.

**Question:** What is the extent of data from this program? Haw do the data from this intersect with your standards and is there a basis for impairment based on these data independent of/combined with the TSI information?

<u>From Part V. Water Quality Assessment; B. Lakes and Reservoirs Water Quality Assessment</u>

<u>Chapter 2. Section 305(b) Water Quality Summary</u>

- For purposes of this report, the term "aquatic life use" is synonymous with biological integrity and is defined as the ability of a lake or reservoir to support and maintain a balanced, adaptive community of aquatic organisms (e.g., fish, zooplankton, phytoplankton, macroinvertebrates, vascular plants) having a species composition, diversity and functional organization comparable to that of least-impaired reference lakes and reservoirs in the region (modified from Karr et al., 1981).

**Question:** This is really cool to have in your IR. Have you ever used biology to assess this in lakes/reservoirs? Do you have reference lakes?

- Low DO in lakes can occur in summer (summer kills), but usually occurs in the winter under ice-cover conditions. Low DO and winter kills occur when senescent plants and algae decompose, consuming available oxygen. Because the lake is ice covered, re-aeration is minimal, and the lake goes anoxic resulting in a fish kill.

**Question:** See question above; do you have winter data? I think you require a winter sample on lakes, do you not? What is done with that data?

- … 29 lakes and reservoirs representing 8,168 acres were assessed as fully supporting, but threatened (Table V-6). A threatened assessment means that if water quality and/or watershed trends continue, it is unlikely these lakes will continue to support aquatic life use. The lakes and reservoirs will begin to experience more frequent algal blooms and fish kills. They will display a shift in trophic status from a mesotrophic or eutrophic condition to a hypereutrophic condition. Only seven (7) lakes, totaling 859 acres, were assessed as not supporting aquatic life use (Table V-6).
- Recreation use (e.g., swimming, waterskiing, boating, sailing, sunbathing) was assessed for 170 lakes and reservoirs in the state totaling 608,107 acres. Of this total, nine (9) lakes, representing 8,510 acres, were assessed as not supporting use for recreation (Table V-6). The <u>primary cause of use impairment is excessive nutrient loading, which results in nuisance algal blooms and noxious aquatic plant growth</u> (Table V-7).

Table V-7. Impairment Summary for Lakes and Reservoirs in North Dakota.

| Impairment | Acres |
|---|---|
| Nutrients | 35,004.5 |
| Oxygen Depletion | 6,598.3 |
| Sedimentation/Siltation | 4,185.0 |
| Turbidity | 1,191.0 |
| Total Dissolved Solids | 36.8 |
| Mercury in Fish Tissues | 448,933.5 |

**Question:** Were determinations in Table V-7 based on the TSI and DO standards?

Chapter 3. Trophic Status

- When sufficient data were available, all classified reservoirs and natural lakes were assessed for trophic status.
- Adequate data were available to assess the trophic status of 174 of the 200 classified lakes and reservoirs entered into ATTAINS. The majority of the state's assessed lakes and reservoirs range from mesotrophic to eutrophic. Thirty (30) lakes and reservoirs were assessed as hypereutrophic.

Table V-8. Trophic Status Summary for Lakes and Reservoirs in North Dakota.

| Trophic Status | Number of Lakes | Acreage of Lakes |
|---|---|---|
| Oligotrophic | 0 | 0.0 |
| Mesotrophic | 54 | 444,108.1 |
| Eutrophic | 90 | 154,358.0 |
| Hypereutrophic | 30 | 15,875.2 |
| Not Assessed | 26 | 8,040.3 |
| Total Number of Lakes | 200 | 622,381.6 |

**Question:** Assessment methodology language (p.20) suggests all hypereutrophic lakes are not supporting fishery and recreational uses, so were all of the acres in Table V-8 impaired? How does this correlate with Table V-7? I am just trying to figure out how decisions for nutrient impairment under the 305b chapter compare to this trophic state chapter.

Chapter 7. Toxic Effects on Lakes and Reservoirs

Harmful Algal Blooms and Cyanotoxins

- Almost every year in North Dakota, a few cases of pet and livestock deaths occur due to drinking water with HABs.

**Question:** Interest in an endpoint?

- Once a waterbody has an excess of nutrients, the problem cannot be fixed overnight. Nutrients must be removed mechanically and/or allowed to be reduced naturally through internal cycling, while limiting the sources of nutrients in the watershed. Several North Dakota lakes have hypolimnetic drawdown systems that remove nutrient-rich water from the bottom of the lake. These systems can be effective at removing nutrients, but they do not address the nutrient sources.

**Question:** Have you considered downstream issues associated with drawdowns from eu or hypereutrophic lakes?

Chapter 8. State-wide Statistical Survey Results for Lakes and Reservoirs

Biological Condition

- The NLA focused on benthic macroinvertebrates and zooplankton.
- Greater than 50 percent of North Dakota lakes (2,002 lakes) were in good condition based on the benthic macroinvertebrate MMI, compared to 13 percent (522 lakes) and 32.5 percent (1,297 lakes) of lakes in fair and poor condition, respectively (Figure V-22)
- With regard biological condition estimated based on the zooplankton MMI, most lakes in North Dakota were considered fair (55 percent; 2,195 lakes), with 15 percent of lakes (586 lakes) in good condition and 30 percent of lakes (1,214 lakes) in poor condition (Figure V-23).

**Question:** Given you biological narrative and the statement at the beginning of Chapter 2 above, what use attainment decisions are these biological data informing, if any? Is there a desire to use such information moving forward?

Stressors to Lake Biota

Nutrients

- For the 2012 NLA and state intensification study, 53 percent of lakes assessed (2,113 lakes) were considered in fair condition for total nitrogen (TN), followed by 46 percent (1,828 lakes) in poor condition and only 1.4 percent (54 lakes) in good condition (Figure V-24). Further, 50.4 percent of lakes assessed in 2012 (2012 lakes) were considered in poor condition for total phosphorus (TP), followed by 41 percent (1622 lakes) in good condition and 9 percent (361 lakes) in fair condition (Figure V-25).

**Question:** What values were used as thresholds for these conclusions? Are they useful as guidelines or future criteria? How do these results correlate with your assessment program determinations?

Suitability for Recreation Use

- The 2012 NLA and state intensification project assessed three indicators with respect to recreational condition: 1) microcystin, a type of algal toxin; 2) cyanobacteria, a type of algae that often produces algal toxins; and 3) chlorophyll-a, a measure of all algae present in the lake.

**Question:** What values were used as thresholds for these conclusions? I assume Cyanobacteria cell count was 100,000 cells/ml and Microcystin was 20 ug/L. What about chlorophyll *a*?

## 1.4 TMDL APPLICATIONS/INTERPRETATIONS:

### Description of Water Body

Matejcek Dam is located on Middle Branch of the Forest River in southeastern North Dakota. The watershed lies almost entirely within Walsh County. Completed in 1966, Matejcek Dam is a 130.4-acre reservoir designed for flood control, recreation, and a farm to market road. The reservoir has a contributing watershed of 88,572 acres. Average depth is approximately 19 feet and maximum depth at 43 feet. Fisheries include walleye, northern pike, and yellow perch (p. 5 of PDF). The surrounding land use consists of the following: 29 percent crop production and 26 percent livestock grazing (p. 8 of PDF).

### POLLUTANT(S) OF CONCERN AND IMPACTS

Aquatic life and recreational uses are impaired due to low DO and nutrient/eutrophication/biological indicators (p. 7 of PDF).

### SOURCES OF NUTRIENT POLLUTION

Nitrogen and phosphorus are pollutants of concern (p. 7 of PDF). Significant sources are nonpoint sources derived from anthropogenic sources in the watershed (p. 23 of PDF).

### WATER QUALITY STANDARDS

There are no numeric nutrient criteria applicable to lakes and rivers in North Dakota. North Dakota uses Carlson's TSI (chl-a, Secchi disc, and TP) to assess its lakes.

For the purposes of this TMDL, "hypereutrophic" lakes do not fully support sport fishery and limited support for recreational uses. North Dakota gives priority to chl-a as the primary TSI because it is the most accurate of the three parameters predicting algal biomass (p. 21 of PDF).

North Dakota sets chl-a concentration guidelines for "Lake Improvement or Maintenance Program" at 20 ug/L during the growing season of April through November (p.19 of PDF). Chl-a of 20 ug/L corresponds with the lower end of the chl-a ranges that Carlson and Simpson (1996) developed to describe a TSI of 60-70, which is described as "hypereutrophy" (p. 50 of PDF). North Dakota and Region 8 determined that **a chl-a concentration of 20 µg/L or less should be the basis for nutrient criteria development for lakes and reservoirs in the plains region** (including North Dakota) and that this chl-a target would be protective of a lake or reservoir's beneficial uses, including recreation and aquatic life (p.21 of PDF).

### TMDL APPROACH

North Dakota used a chl-a value of 20 ug/L that corresponds with a target TSI score of 60 (considered "eutrophic") during the growing season (April through November) (p. 19 of PDF). The BATHTUB model was used to predict and evaluate the effects of various nutrient load reduction scenarios on Matejcek Dam (p. 24 of PDF).

North Dakota looked at available data (2012-2013 growing season), finding that the average growing season concentration was already below the recommended 20 ug/L (p. 14, 25 of PDF).

BATHTUB was used to model the reservoir's trophic status response based on reductions in just externally derived phosphorus and nitrogen loading. Phosphorus and nitrogen were both used in the simulation model based on their known relationship to eutrophication and also that they are controllable with Best Management Practices (BMPs) implemented in the watershed. Changes in trophic response were evaluated by reducing externally derived nutrient (phosphorus and nitrogen) loading by 10 percent, to be protective of current beneficial uses and prevent degradation. Simulated reductions in chl-a, Secchi disk depth, and total phosphorus-based TSI scores were achieved by reducing phosphorus and nitrogen concentrations in contributing tributaries and other externally delivered sources (p. 25 of PDF).

## 1.5 PERMITTING APPLICATIONS/INTERPRETATIONS:

Unknown.

From ICIS: 2017 Nutrient DMR pull indicated 10,541 measures of N (NOx, TKN, TN) and P (TP) from 2003-2017